Chapter 16: POTW Benefits

Introduction

Reducing effluent discharges from the MP&M industry should result in two categories of productivity benefits for ***publicly owned treatment works* (POTWs)**:

- reduced ***interference*** with the operations of POTWs, and

- reduced contamination of sewage sludge (i.e., biosolids) at POTWs that receive discharges from MP&M facilities.

Interference with POTW processes occurs when high levels of toxics, such as metals or cyanide, kill bacteria required for wastewater treatment processes. The MP&M regulation should remove 703 million pounds of 89 such pollutants per year from the wastewater of indirect dischargers (see Table 16.1), thereby reducing the potential for interference with POTW operations. The removal of these pollutants would eliminate the need for extra labor and materials to maintain POTW operations. EPA estimated that the proposed regulation would eliminate potential inhibition problems caused by MP&M facilities at 306 POTWs nationwide. This analysis is presented in Section 16.1.

Toxic priority and nonconventional pollutants may also pass through a POTW and contaminate sludge generated during primary and secondary wastewater treatment.[1] EPA estimates that the proposed regulation would remove 30.1 million pounds per year of the eight pollutants for which there are published sludge concentration limits (see Table 16.1). POTW treatment of wastewater with reduced pollutant concentrations translates into cleaner sludge, which can be disposed of using less expensive and more environmentally benign methods. In some cases, cleaner sludge may have agricultural applications, which would generate additional resource conservation benefits. EPA estimated that potential cost savings for POTWs expected to upgrade their sludge disposal practices under the post-compliance scenario are $61.1 to $61.5 million (1999$). This analysis is presented in Section 16.2.

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Some MP&M pollutants that pass through a POTW and contaminate sludge are not currently subject to sewage sludge pollutant concentration limits. The proposed regulation would reduce concentrations of these pollutants in sewage sludge as well, which may translate into reduced environmental and human health risks. EPA did not estimate the reduced risk attributable to the reduction of these pollutants.

Wastewater from MP&M facilities also ***contains hazardous air pollutants* (HAPs)**. These pollutants may represent unacceptable health risks to POTW workers if released into the air at high enough concentrations during the wastewater treatment cycle. The proposed regulation is expected to remove approximately one million pounds per year of HAPs from wastewater transferred to POTWs. This reduction in pollutants may translate into health benefits to POTW workers and those living near POTWs.

[1] The term sewage sludge, also called biosolids, is often shortened to sludge throughout this chapter for simplicity.

Table 16.1 National Estimates of MP&M Pollutants Loadings

POTW Effects	Baseline	Proposed Option
Activated Sludge Inhibition		
# of Pollutants	89	89
million lbs/yr	1,031	328
Sludge Contamination		
# of Pollutants	8	8
million lbs/yr	31.7	1.61
HAP (Explosivity)		
# of Pollutants	35	35
million lbs/yr	2.1	1.11

Source: U.S. EPA analysis.

16.1 Reduced Interference with POTW Operations

High levels of some MP&M pollutants (such as metals, chlorobenzene, polyaromatic hydrocarbons, and oil and grease) can kill bacteria that are required for the wastewater treatment process (U.S. EPA, 1987). POTWs affected by such "inhibition problems" may incur extra labor and materials costs to maintain system operations. As a partial measure of the economic benefits resulting from the proposed regulation, EPA estimated the extent to which reduced MP&M discharges would decrease pollutant concentrations to below POTW ***pollutant inhibition values***, using the following steps:

- Estimate the baseline and post-compliance ***influent concentrations*** for each POTW receiving discharges from MP&M facilities, based on annual pollutant loadings from the MP&M facility, the number of POTW operating days per year, and the gross volume of influent.

- Compare baseline and post-compliance influent concentrations with available inhibition levels (see Table E.5 in Appendix E).

- Estimate the change in the number of POTWs in which influent concentrations of MP&M pollutants exceed POTW inhibition values.

Adverse effects on POTW operations, including inhibition of ***microbial degradation***, are likely when influent concentrations of one or more pollutants exceed an inhibition value. EPA estimated influent concentrations in excess of POTW inhibition values for the sample facilities, and then extrapolated these findings to national estimates using a differential weighting technique (see Appendix F).

EPA estimated that 515 POTWs had influent concentrations that exceeded biological inhibition values for one or more of 18 pollutants in the baseline. (Table E.12 in Appendix E provides detailed information on pollutants exceeding POTW inhibition criteria.) Exceedances would be eliminated with post-compliance discharge levels under the proposed option for 306 affected POTWs. Eliminating the exceedances will result in operating cost savings to POTWs. EPA has not estimated a monetary value for this benefit, however, due to data limitations.

POTWs may impose local limits to prevent inhibitions. If local limits are in place, the estimated reduction in potential inhibition problems at the affected POTWs is overstated. In this case, however, the estimated social cost of the MP&M regulation is also overstated.

16.2 Assessing Benefits from Reduced Sludge Contamination

16.2.1 Data Sources

The analysis of POTW benefits from improved sludge quality draws on several data sources.

The §308 POTW surveys provide most of the required information. EPA collected information from 147 POTWs representing a 98 percent response rate to the 150 surveys that were mailed. EPA also used the §308 survey of MP&M

facilities. The two data collection efforts were not designed to provide a match between the MP&M sample facilities and the POTWs to which they discharge. EPA obtained a significant amount of information from the POTW surveys, but had substantially less information on the POTWs that receive discharges from the MP&M facilities. To address this data limitation, EPA used the POTW Survey data to infer information on the key factors that are likely to influence choice of sewage sludge use and disposal practices for the POTWs receiving discharges from the MP&M facilities. EPA also used other data sources in this analysis, including *Handbook for Estimating Sludge Management Costs* (EPA, 1985) and *Regulatory Impact Analysis of the Part 503 Sludge Regulation* (EPA, 1993b).

The POTW Survey contains three sections. Section 1 provides general information on POTW location and size. Section 2 provides data on the cost of administering pre-treatment programs (see Appendix C). Section 3 contains data on the cost of treating and disposing of sewage sludge and provides new and more consistent data for analyzing the effect of reduced pollutant loadings on sewage sludge management costs.

The POTW Survey asked for the following information:

- current sludge disposal practices;
- sludge disposal costs for one or more disposal methods;
- reasons for not using a less expensive disposal method;
- number of MP&M facilities discharging to the POTW, by flow size (less than 1 million gal/year; 1-6.25 million gal/year; greater than 6.25 million gal/year);
- total metal loadings discharged to the POTW from all sources; and
- percentage of total metal loadings attributable to MP&M facilities.

The POTW Survey was intended to address data limitations encountered in the Phase 1 analysis, particularly the inadequacy of information about POTWs that receive discharges from the MP&M sample facilities. The only information available for the Phase I analysis was POTW geographic location, influent volume, and the metals content of the discharge received from the sampled MP&M facilities. Discharges to the POTW by non-sampled MP&M facilities and by non-MP&M facilities were not known. These discharges may significantly affect sewage sludge quality, however, resulting in a discrepancy between predicted and actual pollutant concentrations in sewage sludge and the corresponding disposal practices. In addition, lack of information on the factors that may influence a POTW's decisions about sludge management practices introduced additional uncertainty in the analysis.

EPA used the POTW Survey to calculate the following parameters:

- baseline percentage of the total metal loadings to POTWs by POTW flow category attributable to MP&M facilities;
- post-compliance loading reductions for non-sampled MP&M facilities discharging to the receiving POTWs;
- costs of sewage sludge disposal practices; and
- percentage of qualifying sludge that is not beneficially used for any of the following reasons: lack of land; lower cost alternative; inability to meet vector or pathogen requirements; poor weather; stricter state standards; and other reasons.

16.2.2 Sludge Generation, Treatment, and Disposal Practices

a. Sludge generation

POTWs generally treat wastewater from industrial indirect dischargers along with domestic wastewater. Sludge results from primary, secondary, and advanced wastewater treatment. The extent and type of wastewater treatment determine the chemical and physical character of the sludge. Sludge may be conditioned, thickened, stabilized, and dewatered to reduce its volume.

Sludge contains five classes of components: organic matter, pathogens, nutrients, inorganic chemicals, and organic chemicals. The mix and levels of these components ultimately determine the human health and environmental impact of sludge use/disposal, and so may also dictate the most appropriate uses and disposal practices (EPA, 1993b).

Organic matter (the primary constituent of sludge) comes from human waste, kitchen waste, and storm water runoff. Organic and inorganic chemicals in sludge come from industrial processes that discharge to municipal sewers. The concentration of inorganic pollutants in sludge, including metals, depends upon the volume and type of industrial wastes discharged to the POTW, as well as the extent and character of stormwater runoff.

b. Sludge use/disposal practices

After treatment, sludge can be used in the following ways:

- *Land Application:* Spraying or spreading on the land surface, injection below the surface, or incorporation into the soil, for soil conditioning or fertilization of crops or vegetation. Agricultural lands (pasture, range land, crops), forest lands (***silviculture***), and drastically disturbed lands (land reclamation sites) may all receive sludge;

- *Bagged Application:* Collection of sludge in containers for application to land (i.e., distribution and marketing);

- *Surface Disposal:* Disposal on land specifically set aside for this use, including surface impoundments (also called lagoons), sludge monofills (i.e., sludge-only landfills), and dedicated sites (i.e., land on which sludge is spread solely for final disposal);

- *Co-disposal:* Disposal in a ***municipal solid waste landfill*** **(MSWL)** or ***hazardous waste landfill***; and

- *Incineration:* Combustion of organic and inorganic matter at high temperatures in an enclosed device.

Land application and bagged application are beneficial uses of sludge. Both methods can be categorized as being "high" or "low," depending on pollutant concentrations in sewage sludge. "High" applications meet stringent limits on the total concentration of a given pollutant at a given application site. "High" sludge is exempt from meeting pollutant loading rate limits and certain record-keeping requirements. "Low" applications meet less stringent "ceiling" limits for pollutants. Ceiling limits govern whether a sewage sludge can be applied to land at all. "Low" applications require more record-keeping because POTWs must track total (cumulative) loadings applied to each given site, in addition to tracking the concentration of sludge applied at any given time.

Many POTWs use more than one use/disposal practice, which helps to maintain flexibility and avoid the capacity limitations of a single practice. The practice chosen depends on several factors, including:

- cost to prepare sludge for use/disposal;

- pollutant concentrations;

- market demand for sludge;

- cost to transport sludge to use/disposal sites;

- availability of suitable sites for land application, landfilling, or surface disposal;

- weather and other local conditions;

- allowance of a safety factor to account for unplanned or unforseen conditions;

- state environmental regulations; and

- public acceptance (EPA, 1993b).

The choice of use/disposal method is restricted by the quality of the sludge generated by the POTW. Sludge for beneficial uses must meet more stringent standards for pollutant concentrations than sludge used or disposed of in other ways. Similarly, sludge that is surface-disposed in an unlined unit generally must meet more stringent standards than sludge surface-disposed in a lined unit, disposed in an MSWL, or incinerated. Sludge disposed in a MSWL must meet more stringent standards than incinerated sludge.

Table 16.2 summarizes sludge use/disposal methods according to the number and percent of dry metric tons **(DMT)**, based on information provided in Section 3 of the §308 POTW Survey.

Table 16.2: Sludge Use/Disposal (1996) by POTWs Discharging > 2 Million Gallons/Day[a]

Use/Disposal Sub-Class	Thousand DMT	Percent of DMT
Total Beneficial Use	**2,873.4**	**39.2%**
Land Application-High	1,143.6	15.6%
Bag Application-High	351.5	4.8%
Land Application-Low	1,378.3	18.8%
Bagged Application-Low	0	0%
Total Surface Disposal	**572.7**	**7.8%**
Surface Disposal: Unlined Unit	347.2	4.7%
Surface Disposal: Lined Unit	225.5	3.1%
Co-Disposal: Municipal Landfill	**2,213.5**	**30.2%**
Incineration	**1,129.9**	**15.4%**
Unknown: Other	**543.2**	**7.4%**
All	**7,332.6**	**100.0%**

a. The §308 POTW Survey did not collect information from POTWs discharging < 2 million gallons per day.
Source: U.S. EPA, POTW Survey.

As Table 16.2 shows, 39 percent of total sludge tons reported by respondents is used beneficially (land application and bagged application). Co-disposal in a municipal landfill is the second most frequently used disposal method, accounting for 30.2 percent of all sludge disposed in the U.S. Surface disposal in unlined and lined units, incineration, and "other" disposal methods account for 4.7 percent, 3.1 percent, 15.4 percent, and 7.4 percent of all sludge tons, respectively. No sludge was sent to a hazardous waste landfill by the POTW Survey respondents.

c. Pollutant limits and disposal options

Section 405(d) of the Clean Water Act, as amended, requires EPA to specify acceptable management practices and numerical limits for certain pollutants in sludge. The Agency published *Standards for the Use/Disposal of Sludge* (40 CFR Part 503, February 1993) to protect public health and the environment from reasonably anticipated adverse effects of pollutants in sludge (U.S. EPA, 1993a). The standards include general requirements, pollutant limits, management practices, operational standards, monitoring frequency, record-keeping, and reporting for the final use and disposal of sludge in four circumstances:

- sludge co-disposed with household waste in an MSWL;
- sludge land-applied for beneficial purposes (including bagged sludge);
- sludge disposed on land or on surface disposal sites; and
- incinerated sludge.

With the exception of MSWLs, the standards for each practice include numerical limits on sludge pollutant concentrations. Part 503 sets limits on pollutant concentrations for land application at two levels:

- Land Application-Low limits, which govern whether a sludge can be applied to land at all; and
- more stringent Land Application-High limits which define, in part, sludge that is exempt from meeting certain record-keeping requirements.

For sludge meeting only the Land Application-Low limits, Part 503 contains pollutant loading rate limits. These determine the amount of sludge and associated pollutant content that may be applied to a particular site.

EPA did not establish pollutant-specific, numerical criteria for toxic pollutants of concern in the sludge disposed in MSWLs, because the design standards applicable to MSWLs are considered adequate to protect human health and the environment. Also, MSWL sludge is co-disposed with household waste, making precise numerical criteria infeasible. The *Solid Waste Disposal Facility Criteria* (40 CFR Part 258, Federal Register 50978, October 9, 1991) specify that POTWs using an MSWL must ensure that their sewage is non-hazardous and passes the Paint Filter Liquid Test.

The pollutant limits for sludge land application, surface disposal, and incineration constrain a POTW's choice of sludge use/disposal practice. Table 16.3 presents numerical limits for the three sludge use/disposal practices for eight MP&M pollutants. The land application pollutant limits place restrictions on concentrations of metals in sludge; the surface disposal criteria cover a subset of the metals regulated for land application. The MP&M effluent limitations guideline covers five metals and causes incidental removal of the remaining three metals regulated under the Part 503 sludge regulation. The proposed regulation would improve quality of sewage sludge generated by POTWs receiving discharges from MP&M facilities and, as a result, would increase sludge use/disposal options for the affected POTWs.

Table 16.3: Sludge Use/Disposal Pollutant Limits

Pollutant	Application Limits: Low Limits (Low) (mg/kg dry weight)	Application Limits: High Limits (High) (mg/kg dry weight)	Surface Disposal Limits (mg/kg dry weight)[a]	MP&M Pollutants of Concern
Arsenic	75	41	73	✔
Cadmium	85	39		✔
Copper	4,300	1,500		✔
Lead	840	300		✔
Mercury	57	17		✔
Nickel	420	420	420	✔
Selenium	100	36		✔
Zinc	7,500	2,800		✔

a. Pollutant limits for active sludge unit whose boundary is greater than 150 meters from the surface disposal site property line.
Source: Standards for the Use or Disposal of Sludge; Final Rules. 40 CFR Part 257 et al. Federal Register February 19, 1993.

d. Reasons for not land-applying qualifying sludge

POTW characteristics including location, state regulations, and community concerns also affect use/disposal methods for sludge. The POTW Survey provided information on the percentage of sludge that qualified for beneficial use but was not beneficially used. Survey data indicate that 52 percent of qualifying sludge was not land-applied, for the following reasons:

- land application is more expensive than another method;
- land is not available for sludge application;
- the cumulative pollutant loads at the land application site used had been exceeded;
- the ***vector*** or ***pathogen*** requirements to land apply could not be met at an acceptable cost; and
- inclement weather, concern over liability, stakeholder complaints, stricter state standards, desire to diversify practices, or technical problems.

Of the 52 percent of sludge that was not land-applied, only 12 percent of qualifying sludge was otherwise beneficially used (i.e., sold in bags). Therefore, only 54 percent of the total qualifying sludge is beneficially used.[2] In addition, POTW Survey data indicate that, on average, 7.5 percent of all sludge that qualifies for surface disposal is not surface disposed.

16.2.3 Overview of Improved Sludge Quality Benefits

This section discusses potential economic productivity benefits resulting from cleaner sludge, describes the methodology used to estimate benefits to POTWs directly affected by the regulation, and presents the results of the analysis.

EPA expects the proposed regulation to reduce MP&M facility discharges of eight metals with Part 503 limits. The influent pollutant reductions to these POTWs translate into sludge with reduced pollutant concentrations, allowing the sludge to meet the criteria for lower-cost use/disposal methods. The reduction in pollutants will then provide many POTWs with greater flexibility in the disposal of their sludge, and for some the opportunity to use less expensive methods of sludge use/disposal. In some cases, wastewater treatment systems may be able to use the cleaner sludge in agricultural applications, generating additional agricultural

[2] Percent Beneficially Used = (100% − 52%) +{(52% × 12%)/100%}.

productivity benefits. Numerous benefits will result from reduced contamination of sludge, including the following:

- POTWs may have less expensive options for use/disposal of sludge. Methods involving stricter criteria pollutants are generally less expensive than the alternatives. In particular, land application usually costs substantially less than incineration or landfilling. As a result of the proposed regulation, sludge from some POTWs may meet more stringent criteria for less expensive use/disposal methods.

- Some sludge currently meeting only Land Application-Low Concentration limits and pollutant loading rate limits would meet the more stringent Land Application-High Concentration limits. Users applying sludge meeting Land Application-High pollutant limits would be exempt from meeting pollutant loading rate limits. They would have fewer record-keeping requirements than users of sludge meeting only Land Application-Low concentration and loading rate limits.

- By land-applying sludge, POTWs may avoid costly siting negotiations for more contentious sewage sludge use or disposal practices, such as incineration.

- POTW sludge provides supplemental nitrogen, which enhances soil productivity when land-applied. Sludge applied to agricultural land, golf courses, sod farms, forests, or residential gardens is a valuable source of nitrogen fertilizer.

- Nonpoint source nitrogen contamination of water may be reduced if sludge is used as a substitute for chemical fertilizers on agricultural land. Compared to nitrogen in most chemical fertilizers, nitrogen in sludge is relatively insoluble in water. The release of nitrogen from sludge occurs largely through continuous microbial activity, resulting in greater plant uptake and less nitrogen runoff than from conventional chemical fertilizers.

- The organic matter in land-applied sludge can improve crop yields by increasing the ability of soil to retain water.

- Reduced concentrations of sludge pollutants not currently regulated may reduce human health and environmental risks. Human health risks from exposure to these unregulated sludge pollutants may occur from particulate inhalation, dermal exposure, ingestion of food grown in sludge-amended soils, ingestion of surface water containing sludge runoff, ingestion of fish from surface water containing sludge runoff, or ingestion of contaminated ground water.

- Land application of sludge satisfies an apparent public preference for this practice of sludge disposal, apart from considerations of costs and risk.

This analysis assumes that POTWs will choose the least expensive sludge use/disposal practice for which their sludge meets pollutant limits. POTWs with sludge pollutant concentrations exceeding the Land Application-High, Land Application-Low, or surface disposal pollutant limits in the baseline may be able to reduce sludge use/disposal costs after MP&M facilities have complied with the proposed effluent limitations.

As public entities, POTWs are not forced by the market to act as profit-maximizing or cost-minimizing agents, but rather are assumed to optimize their jurisdictional welfare function. POTWs take factors other than cost into consideration when determining their sludge use/disposal methods. These factors may include the desire to be perceived by the public as using sludge in an environmentally friendly way, or the desire to enhance relationships with clients by providing no-cost or low-cost fertilizer. Greater flexibility in disposal practices may therefore provide benefits beyond cost savings.

16.2.4 Sludge Use/Disposal Costs and Practices

This section summarizes the estimated cost differences of various use and disposal methods, based on the POTW Survey.

Alternative sludge use/disposal practices costs vary considerably among POTWs, based on several factors, the most important being the availability of local agricultural land or land suitable for surface disposal of sludge. Table 16.4 lists and ranks the use/disposal methods from least expensive to most expensive, according to the average qualitative ranking of each method in the POTW Survey.

Table 16.4: National Estimate of Qualitative Ranking of Use/Disposal Methods

	Mean Rankings
Least Expensive	Land Application-High
↕	Land Application-Low
	MSWL
↕	Bagged Application-High
	Surface Disposal in Unlined Unit
↕	Bagged Application-Low
	Surface Disposal in Lined Unit
↕	Incineration
Most Expensive	Hazardous Waste Landfill

Source: U.S. EPA, §308 POTW Survey.

Land Application-Low and Land Application-High were ranked as the two cheapest sewage sludge disposal options, supporting the assumption that beneficial use of sludge offers cost savings. The third least expensive option — co-disposal in an MSWL — costs less on average than either bagging sludge or surface disposing in an unlined unit.

EPA used the POTW Survey data as the primary source for estimating an average *difference* in costs among certain combinations of use/disposal practices (e.g., the cost savings achieved by switching from incineration to land application). Table 16.5 compares the cost savings realized by switching to sludge land application and surface disposal practices from less stringently regulated sludge use/disposal practices. While on average the estimates provided in Table 16.5 are expected to hold, the cost savings will vary for individual POTWs. POTWs whose sludge qualifies for beneficial use post-compliance but did not qualify for such use in the baseline may achieve cost savings in some, but not all, circumstances. For example, a POTW may not achieve cost savings from agricultural application due to sludge transportation costs or because there are less expensive alternatives for that particular facility. Switching from sewage sludge co-disposal in a MSWL to surface disposal offers no savings to a POTW.

Table 16.5: Cost Savings for Shifts in Sludge Use/Disposal Practices (1999$/DMT)

	Switch To:				
Switch From:	**Land Application[a] (High)**	**Land Application[a] (Low)**	**Sold in a Bag for Land Application**	**Surface Disposal on Unlined Unit**	**Surface Disposal on Lined Unit**
Incineration	$99.20	$99.20	$91.65	$98.5	No Saving
Surface Disposal on Lined Unit	$120.77	$120.77	$68.69		
Surface Disposal on Unlined Unit	$6.15	$6.15	$0.56		
Co-disposal: MSWL	$95.95	$97.95	$66.85	No Saving	No Saving
Land Application-Low	$0.65-1.30				

a. EPA assumes that the costs of land application to forests, public contact sites, and reclaimed land are similar to the costs of agricultural application.
Source: U.S. EPA analysis of the §308 POTW Survey data.

The cost section of the POTW Survey did not distinguish between low and high land application or low and high bagged application. Therefore, costs provided in the survey reflect the cost of both methods. To estimate the cost savings of avoiding these requirements by meeting Land Application-High limits, EPA used the compliance requirements for meeting Land Application-Low limits for bulk sludge (U.S. EPA, 1997). These cost savings provide a partial measure of the monetary benefit of improved sludge quality.

EPA estimates that the incremental record-keeping associated with the cumulative Land Application-Low limits requires two to four hours per application. Materials costs for meeting these requirements should be negligible. EPA estimated the record-keeping costs avoided from upgrading sludge quality from Land Application-Low to Land Application-High standards, using the following assumptions:

- a 40-acre site is a typical site size for land application (approximately 16 hectares) (US EPA, 1997);
- the typical application rate for land application is 7 DMT per hectare per application (US EPA, 1997); and
- labor at POTWs costs an average of $37 per hour (1999$), based on the §308 POTW Survey.[3]

Based on these assumptions, EPA estimated that $0.65 to $1.30 would be saved per DMT of sludge upgraded from Land Application-Low to Land Application-High.[4]

16.2.5 Quantifying Sludge Benefits

EPA estimated the number of POTWs receiving MP&M discharges and the associated quantity of sludge that would not meet Land Application-High pollutant limits, Land Application-Low pollutant limits, or surface disposal pollutant limits under both the baseline and regulatory options. EPA then assumed that, as a result of compliance with the MP&M effluent limitations guideline, a POTW meeting all pollutant limits for a less costly sludge use/disposal method would benefit from the reduced cost of that particular method. EPA estimated the reduction in sludge use/disposal costs using the steps described below:

1. Estimate total industrial baseline and post-compliance loadings of Part 503 regulated metals for each POTW with MP&M sample facility discharges;
2. Calculate the baseline and post-compliance sludge pollutant concentrations for all MP&M wastewater discharged to the POTW;
3. Compare POTW sludge pollutant concentrations with sludge pollutant limits for surface disposal and land application;
4. Estimate baseline and post-compliance sludge use/disposal practices based on the estimated pollutant concentrations in sewage sludge;
5. Identify POTWs that upgrade their sewage sludge disposal practices under the proposed option; calculate the economic POTW benefits by multiplying the cost savings for the shift in practices by the quantity of newly qualified sludge. Adjust the estimate of benefits for the percentage of POTWs that cannot land apply sewage sludge due to transportation costs or other reasons, such as cold temperature; and
6. Estimate national benefits using MP&M sample facility weights.

a. Step 1: Estimate total industrial baseline and post-compliance loadings of Part 503 regulated metals

EPA estimated the quantities of Part 503 metals discharged to POTWs receiving wastewater from MP&M sample facilities and facilities operating in other metal discharging industries.[5] EPA used POTW Survey data to estimate the total metal loadings and percent of total loadings discharged to POTWs by MP&M facilities.

The POTW Survey provides the following information:

- number of known MP&M facilities discharging to the POTW,
- total loadings of each regulated metal received by the POTW, and
- percent of the total metal loadings attributable to MP&M industries.

Table 16.6 summarizes this information by POTW flow volume.

[3] See Appendix C of this EIA for detail.

[4] Savings per DMT are calculated by dividing the estimated labor cost per application ($37 per Hour * Hours per Application) by the total amount of sludge disposed of per one application (16 Hectares * 7 DMT per hectare).

[5] EPA did not include metals from residential wastewater due to lack of data. The effect on the analysis of omitting residential metal loadings is not known.

Table 16.6: MP&M Contribution to Total Industrial Loadings Received by POTWs

MP&M Contribution	POTW size (million gallons per day) 2-10	11-50	>50
MP&M facilities	***Average number of MP&M facilities per POTW***		
small (<1 MG/year)	33.0	106.0	269.6
medium (1-6.25 MG/year)	2.5	9.1	85.0
large (>6.25 MG/year)	1.2	2.9	16.3
Chemicals	***MP&M percentage of total loadings by weight***		
Arsenic	7.4	14.0	7.0
Cadmium	16.1	23.4	12.8
Copper	18.9	21.6	10.9
Lead	13.8	19.8	10.3
Mercury	7.9	20.8	6.0
Nickel	25.1	24.4	15.8
Selenium	7.2	8.5	3.3
Zinc	20.2	16.0	8.2

Source: U.S. EPA, §308 POTW Survey.

EPA estimated total baseline metal loadings from all MP&M sources, as follows:

$$PLM_{k,\ i} = \frac{LMP_{small,\ k,\ i} \times Avg\ \ Num\ \ Sm}{Sample\ \ Sm} + \frac{LMP_{medium,\ k,\ i} \times Avg\ \ Num\ \ Med}{Sample\ \ Med} + \frac{LMP_{large,\ k,\ i} \times Avg\ \ Num\ \ Lg}{Sample\ \ Lg} \tag{16.1}$$

where:

- $PLM_{k,i}$ = Baseline loadings of pollutant *k* to POTW; from all MP&M sources (µg/year);
- $LMP_{small,k,i}$ = loadings of pollutant *k* from small (< 1 MG/year) sample MP&M facilities, discharging to POTW *i* (µg/year);
- AvgNumSm = the average number of small MP&M facilities discharging to POTW *i*; EPA estimated the average number of MP&M facilities of a given size (small, medium, large) that discharge to POTWs in given flow categories, based on the §308 POTW Survey (see Table 16.6);[6,7]
- SampleSm = number of MP&M small (< 1 MG/year) sample facilities discharging to POTW;
- $LMP_{medium,k,i}$ = loadings of pollutant *k* from medium (1-6.25 MG/year) sample MP&M facilities, discharging to POTWs (µg/year);
- AvgNumMed = the average number of medium MP&M facilities discharging to POTW *i* (based on the POTW flow category (see Table 16.6));
- SampleMed = number of MP&M medium (1-6.25 MG/year) sample facilities discharging to POTW *i*;
- $LMP_{large,k,i}$ = loadings of pollutant *k* from large (>6.25 MG/year) sample MP&M facilities discharging to POTW *i* (µg/year);
- AvgNumLg = the average number of large MP&M facilities discharging to POTW *i* (based on the POTW flow category (see Table 16.6)); and
- SampleLg = number of MP&M large (>6.25 MG/year) sample facilities discharging to POTW *i*.

[6] EPA classified MP&M facilities as small, medium, and large flow in the POTW Survey, based on their discharge volume.

[7] This analysis considers the following POTW flow categories: (1) from 2 MG/day to10 MG/day; (2) from 11 to 50 MG/day; and (3) greater than 50 MG/day.

EPA estimated total baseline metal loadings from all industrial sources using data from the POTW Survey, as follows:

$$PL_{k,\ i} = \frac{PLM_{k,i} \cdot 100\%}{\%MP_k} \qquad (16.2)$$

where:

$PL_{k,i}$	=	total baseline loadings of pollutant *k* from all industrial sources to POTW *i* (µg/year),
$PLM_{k,i}$	=	baseline loadings of pollutant *k* to POTW *i* from all MP&M sources (µg/year),
100%	=	the total reported POTW transfers of pollutant *k* from all industrial sources, and
$\%MP_{,k}$	=	the percentage of total reported POTW transfers of pollutant *k* from MP&M facilities in a given POTW flow category (see Table 16.6),

Post-compliance pollutant loadings to POTWs are calculated by subtracting the reduction in MP&M loadings due to the regulation from the estimated total baseline loadings.

b. Step 2: Calculate baseline and post-compliance sludge quality

First, for each metal with limits under the Part 503 regulation, EPA calculated POTW influent concentrations based on the pollutant loading and POTW flow rates, as follows:

$$IC_{k,i} = \frac{PL_{k,i}}{FL_i \times OD_{ise}} \qquad (16.3)$$

where:

$IC_{k,i}$	=	POTW influent concentration of pollutant *k* (µg/liter) for POTW *i*;
$PL_{k,i}$	=	total loading of pollutant k to POTW *i* (µg/year) ;
Fl_i	=	POTW *i* flow (liters/day); and
OD_i	=	POTW *i* operation days (365 days/year).

Second, EPA calculated sludge pollutant concentrations for each pollutant:

$$PC_{k,i} = IC_{k,i} \times TRE_k \times PF_k \times SG \qquad (16.4)$$

where:

$PC_{k,i}$	=	concentration of pollutant *k* in POTW *i* sludge (mg/kg or ppm),
$IC_{k,i}$	=	POTW *i* influent concentration of pollutant *k* (µg/liter or ppb),
TRE_k	=	treatment removal efficiency for pollutant *k* (unitless),
PF_k	=	sludge partition factor for pollutant *k* (unitless), and
SG	=	sludge generation factor ((L-mg)/(µg-kg) or ppm/ppb).

The partition factor represents the fraction of the pollutant load expected to partition to sludge during wastewater treatment. This factor is chemical-specific. EPA used 1988 data on volume of sewage sludge produced (Federal Register, February 19, 1993, p.9257) and volume of wastewater treated (1988 Needs Survey, Table C-3) to estimate the sludge generating factor. The estimated sludge generation factor is 7.4, indicating that concentration in sludge is 7.4 ppb dry weight for every 1 ppb of pollutant removed and partitioned to sludge.

c. Step 3: Compare sludge pollutant concentrations at each POTW with limits for surface disposal and land application

EPA next compared sludge baseline and post-compliance pollutant concentrations to pollutant limits for land application and surface disposal using the following formula:

$$SE_p = 1 \;\; if \;\; \frac{PC_k}{CR_{k,p}} > 1 \qquad (16.5)$$

where:

SE_p	=	sludge exceeds concentration limits for disposal or use practice, *p*;
PC_k	=	sludge pollutant, *k*, concentration; and
$CR_{k,p}$	=	sludge pollutant, *k*, criterion for disposal or use practice, *p*.

If *any* sludge pollutant concentration at a POTW exceeds the pollutant limit for a sludge use/disposal practice in the baseline (i.e., PC/CR >1), then EPA assumed that the POTW cannot use that sludge use/disposal practice. If, as a result of compliance with the MP&M regulation, a POTW meets all pollutant limits for a sludge use/disposal practice (i.e., PC/CR $\leq$ 1), that POTW is assumed to benefit from an increase in sludge use/disposal options.

d. Step 4: Estimate baseline sludge use/disposal practices at POTWs that can meet land application or surface disposal pollutant limits post-compliance

Benefits from changes in sludge use/disposal practices depend on the baseline practices employed. EPA assumes that POTWs choose the least expensive sludge use/disposal practice for which their sludge meets pollutant limits. POTWs with sludge qualifying for land application in the baseline are assumed to dispose of their sludge by land application; likewise, POTWs with sludge meeting surface disposal pollutant limits (but not land application pollutant limits) are assumed to dispose of their sludge on surface disposal sites.

EPA assumed that the mix of surface disposal practices employed by POTWs in the baseline (e.g., surface disposal on a lined unit and surface disposal on an unlined unit) matches that of national surface disposal practices as calculated from the POTW Survey (see Table 16.2).

POTW Survey data indicate that 24 percent of total sludge meeting Land Application-High standards is sold in bags and 76 percent is land-applied. None of the sludge meeting Land Application-Low standards is sold in bags. Each POTW meeting Land Application-High standards in the post-compliance scenario is assumed to sell 24 percent of its sludge in bags and to land-apply the remainder.

The POTW Survey shows that 39 percent of total surface disposed sludge is disposed of in lined units and 61 percent in unlined units. This mix of surface disposal practices may not match the actual sludge disposal surface practices of any individual POTW. In aggregate, however, the assumed surface disposal practices are consistent with actual POTW sludge surface disposal practices. Survey data also showed that, on average, 7.5 percent of all sludge that qualifies for surface disposal was not surface disposed.

POTWs generating sludge exceeding land application and surface disposal pollutant limits in the baseline are assumed to either incinerate sludge or place sludge in a MSWL. The survey indicates that 34 percent of sludge not land-applied or deposited in surface disposal sites is incinerated and 66 percent is placed in MWSLs. Each POTW exceeding surface disposal and land application limits in the baseline is assumed to incinerate 34 percent of its sludge and co-dispose of the remainder. Again, this mix of sludge use/disposal practices may not match the actual sludge disposal practices of any single POTW; in aggregate, however, the assumed distribution corresponds to actual practices.

Using the sludge disposal cost differentials from Table 16.5, EPA estimated savings for shifts into land application and surface disposal from the assumed mix of baseline use/disposal practices (see Table 16.7). As previously discussed, EPA assumed that 46 percent of sludge could not be used beneficially (land-applied or sold in bags) and disposed less expensively through agricultural application of sludge due to transportation costs, land availability, or weather constraints. The Agency did not estimate benefits for this percentage of the sludge newly qualified for land application.

e. Step 5: Calculate economic benefits for POTWs receiving wastewater from sample MP&M facilities

Table 16.7 shows the cost savings for shifts from composite baseline sludge use/disposal practices to land application or surface disposal. Reductions in sludge use/disposal costs are calculated for each POTW receiving wastewater from a MP&M facility, using the following formula:

$$SCR_i = FL_i \times \frac{S}{2200} \times CD_i \tag{16.6}$$

where:

- SCR_i = estimated sludge use/disposal cost reductions resulting from the proposed regulation for POTW *i* (1999$);
- FL_i = POTW *i* wastewater flow (million gallons/year);
- S = sludge to wastewater ratio, assumed to be 1,127 lbs. (dry weight) per million gallons of water (lbs./million gallons) and divided by 2,200 to convert pounds to metric tons; and
- CD_i = estimated cost differential between least costly composite baseline use/disposal method for which POTW *i* qualifies and least costly use/disposal method for which POTW *i* qualifies post-compliance (1999$/DMT).

Table 16.7: Cost Savings from Shifts in Sludge Use/Disposal Practices from Composite Baseline Disposal Practices (1999$/DMT)

	Post-Compliance POTW Sludge Use/disposal Practice			
Baseline POTW Mix of Sludge Use/Disposal Practices	**Agricultural Application-High (76% of sludge meeting Land Application-High pollutant limits)**	**Bagged Sludge (24% of sludge meeting Land Application-High pollutant limits)**	**Agricultural Application-Low**	**Surface Disposal[a] (Meet surface pollutant limits; do not meet land application pollutant limits)**
Meets Land Application-Low pollutant limits, but not Land Application-High limits	\$0.65-\$1.30	N/A[b]	N/A	N/A
Meets surface disposal pollutant limits, but not Land Application-Low limits Assumed disposal mix: 39% lined unit 61% unlined unit	 \$120.77 \$6.15	 \$68.69 \$0.56	 \$120.77 \$6.15	N.A.
Does not meet land application pollutant limits or surface disposal pollutant limits Assumed disposal mix: 34% incineration, 66% co-disposal	 \$99.20 \$95.97	 \$91.65 \$66.85	 \$99.20 \$95.97	 \$0-\$98.5 N/A

a. Surface disposal includes monofills, surface impoundments, and dedicated sites.
b. Not applicable (i.e., there is no cost savings).
Source: U.S. EPA, POTW Survey.

EPA assumed that only 54 percent of the sludge qualified for land application is beneficially used (i.e., land-applied or sold in bags). The remaining 46 percent of the sludge newly qualified for land application will be disposed of by other methods. EPA assumed that no cost savings will be associated with 46 percent of the sludge qualified for land application. To ensure that these benefits are not overstated, this analysis includes an adjustment to the estimate of national sludge use/disposal cost benefits for POTWs that may be located at some distance from agricultural sites. This adjustment does not apply to benefits from shifts into surface disposal.

f. Step 6: Estimate national sludge benefits

EPA scaled the sludge use/disposal cost reductions to the national level as follows:

$$NSCR = \sum_{i=1}^{n} (FW_i \times SCR_i) \qquad (16.7)$$

where:

$NSCR$ = national estimated sludge use/disposal cost reductions resulting from the proposed regulation (1999\$);

n = number of POTWs estimated to shift into meeting surface disposal or land application pollutant limits as a result of MP&M effluent limitations;

FW_i = facility sample weights for facility or facilities discharging to POTW *i*; and

SCR_i = estimated sludge use/disposal cost reductions resulting from the proposed regulation for POTW *i* (1999\$).

16.3 Estimated Savings in Sludge Use/Disposal Costs

Of the POTWs receiving discharge wastewater from MP&M facilities, 6,953 POTWs exceed the Land Application-High pollutant limits and 4,714 exceed the Land Application-Low pollutant limits under the baseline discharge levels. EPA estimated that 62 POTWs will be newly qualified for lower-cost land application based on estimated reductions in sludge contamination. EPA also estimated that 21 POTWs that previously met only the Land Application-Low limits would, as a result of regulation, meet the more stringent Land Application-High limits.

Table 16.8: POTW Exceeding Land Application Limits in the Baseline and Under the Proposed Rule

Numbers of POTWs Exceeding the Limits	Baseline	Proposed Rule	Change
Land Application-High	6,953	6,889	64
Land Application-Low	4,714	4,652	62

Source: U.S. EPA analysis.

EPA used the estimated sludge use/disposal cost differentials presented in Table 16.7 to calculate cost savings for the POTWs expected to upgrade their sludge disposal practices. The benefits are estimated at $61.1 to $61.5 million (1999$) annually for the proposed option. Table 16.9 shows the cost savings by shift in disposal method.

These estimated benefit values reflect only part of the economic benefits expected to result from reduced pollutant concentrations in MP&M discharges to POTWs, and the lower pollutant concentrations of the resulting sludge. EPA expects but did not quantify additional benefits from meeting the Land Application-High limits:

1. If a POTW's sludge meets Land Application-High limits, farmers may be more easily convinced to take the sludge, reducing the time a POTW has to spend to locate application sites.

2. POTWs may be able to sell the sludge they currently give away.

3. Composted sludge may command a higher price than received for composted sludge subject to annual limits (which apply when the sludge does not meet Land Application-High limits).

4. Facilities whose land application is limited only by vectors could decide to meet the more stringent Class A pathogen and vector attraction reduction requirements (by composting sludge, for example) if the subsequent product is not subject to any Part 503 requirements, increasing its ease of distribution.

These benefits are not easily monetized.

Table 16.9: National Estimate of Cost Savings from Shifts in Sludge Use/Disposal Under the Proposed Option

Shift	Category/Number of POTWs	Associated Sludge Quantity (DMT/Year)	Estimated Benefits (million 1999$)
Upgrade from minimum Land Application-Low limits to Land Application-High pollutant limits	21	510,600	$0.33 to $0.66
Upgrade from not meeting land application or surface disposal limits to Land Application-High pollutant limits	43	661,227	$32.9
Upgrade from not meeting land application or surface disposal limits to Land Application-Low pollutant limits	19	529,945	$27.9
Total	83	1,701,712	$61.1 to $61.5

Source: U.S. EPA analysis.

16.4 Methodology Limitations

EPA used the POTW Survey to develop estimates of the cost-saving differentials for the various sludge use/disposal practices. Sludge use/disposal costs vary by POTW. The POTWs affected by the MP&M regulation may face costs that differ from those estimated. As a result, the analysis may over- or under-estimate the cost differentials.

POTW Survey data were also used to estimate metal loadings to POTWs in the baseline analysis. There are two major limitations associated with this approach:

- The baseline metal loadings from individual MP&M facilities of interest may differ from this estimate. The effect of using the §308 survey data to characterize the POTWs that receive MP&M discharges is therefore not known.

- The total share of metals coming from MP&M facilities is likely to be underestimated because lower flow MP&M facilities are not always known by the POTW. During the pretest of the MP&M POTW questionnaire, POTWs told EPA that they were not aware of many of the lower flow facilities that were discharging to them. the POTW would have to use the phone book in order to find and permit these facilities. EPA is consequently proposing to exempt low flow facilities in the general metals and only oily wastes indirect discharge categories.

This analysis assumes that the mix of disposal practices estimated for a specific POTW may not match the actual sludge disposal practices used by that POTW. We know that the mix in the aggregate, as confirmed by the POTW Survey, is correct. The practices used in this analysis are therefore consistent with actual POTW sludge surface disposal practices. Because accurate assumptions for specific POTWs could not be made, the analysis may over- or underestimate the cost differentials.

EPA did not estimate changes in risk associated with changes in sludge. Nor did EPA estimate the productivity benefits of removing any pollutants from the sludge other than the eight metals discussed above.

EPA quantified, but did not monetize economic benefits from reducing interference with POTW operations. EPA did not estimate cost reductions that occur at POTWs with sludge inhibition problems caused by MP&M discharges. These omissions thereby underestimate the benefits of the regulation.

GLOSSARY

hazardous air pollutants (HAPs): air pollutants that are not covered by ambient air quality standards but which, as defined in the Clean Air Act, may present a threat of adverse human health effects or adverse environmental effects. Such pollutants include asbestos, beryllium, mercury, benzene, coke oven emissions, radionuclides, and vinyl chloride. MP&M pollutants include but are not limited to: chlorobenzene, dioxin,1,4-, isophorone, and pyrene.
(http://www.epa.gov/OCEPAterms/hterms.html)

hazardous waste landfill: an excavated or engineered site where hazardous waste is deposited and covered.
(http://www.epa.gov/OCEPAterms/hterms.html)

influent concentrations: measure of a pollutant's concentration in wastewater being received by a POTW for treatment (See also: pollutant inhibition values).

interference: is the obstruction of a routine treatment process of POTWs that is caused by the presence of high levels of toxics, such as metals and cyanide in wastewater discharges. These toxic pollutants kill bacteria used for microbial degradation during wastewater treatment (See: microbial degradation).

microbial degradation: the breakdown of organic molecules via biochemical reactions occurring in living microorganisms such as bacteria, algae, diatoms, plankton, and fungi. POTWs make use of microbial degradation for wastewater treatment purposes. This process is inhibited by the presence of toxics such as metals and cyanide because these pollutants kill microorganisms.

municipal solid waste landfill (MSWL): common garbage or trash generated by industries, businesses, institutions, and homes. Also known as municipal solid waste. (http://www.epa.gov/OCEPAterms/mterms.html)

pathogens: microorganisms (e.g., bacteria, viruses, or parasites) that can cause disease in humans, animals and plants. (http://www.epa.gov/OCEPAterms/pterms.html)

pollutant inhibition values: determined threshold concentration for a pollutant, which when exceeded by the pollutant's influent concentration in wastewater received for treatment will have adverse effects on POTW operations, such as inhibition of microbial degradation (See: microbial degradation).

publicly owned treatment works (POTWs): a treatment works as defined by section 212 of the Act, which is owned by a State or municipality. This definition includes any devices or systems used in the storage, treatment, recycling, and reclamation of municipal sewage or industrial wastes of a liquid nature.
(http://www.epa.gov/owm/permits/pretreat/final99.pdf)

silviculture: management of forest land for timber.
(http://www.epa.gov/OCEPAterms/sterms.html)

vector: 1. An organism, often an insect or rodent, that carries disease. 2. Plasmids, viruses, or bacteria used to transport genes into a host cell. A gene is placed in the vector; the vector then "infects" the bacterium.
(http://www.epa.gov/OCEPAterms/vterms.html)

Acronyms

DMT: dry metric tons
HAPs: hazardous air pollutants
MSWL: municipal solid waste landfill
POTWs: publicly-owned treatment works

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